

iccMAX

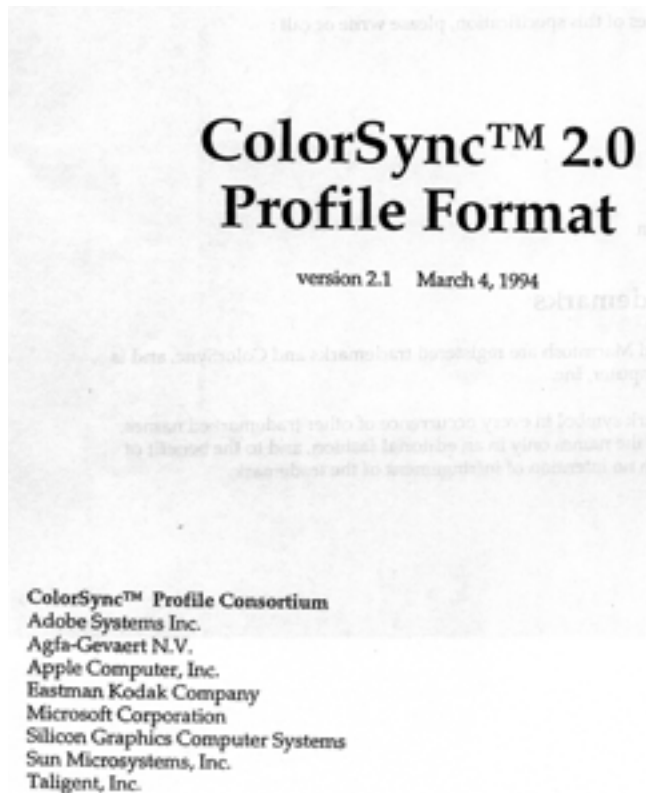
Why does it matter to
you?



International Color Consortium

- Motto: Making color seamless between devices and documents
- Formation: 1993
- Purpose: Promote the use and adoption of open, vendor-neutral, cross-platform color management systems

ColorSync™ Profile Consortium



ICC Profile specification

- 2.0: 1994-06
- 2.4: 2001-04
- 4.0: 2001-12
- 4.3: 2010-12
 - ISO 15076-1:2010
- 5.0: 2015-01
 - extension to ISO 15076

Adobe & ICC

- when did Photoshop support ICC profiles?
 - 2000, limited to RGB and CMYK
 - today still limited support for multi-channel profiles

iccMAX

- The ICC has achieved its initial goal: a color management architecture that allows for the communication of color across devices, applications and operating systems
- In the future, the architecture will be broadened to fit additional color workflows, and specifications tightened further to improve interoperability
- This effort is being managed under the name **iccMAX**

ICC v4 Limitations

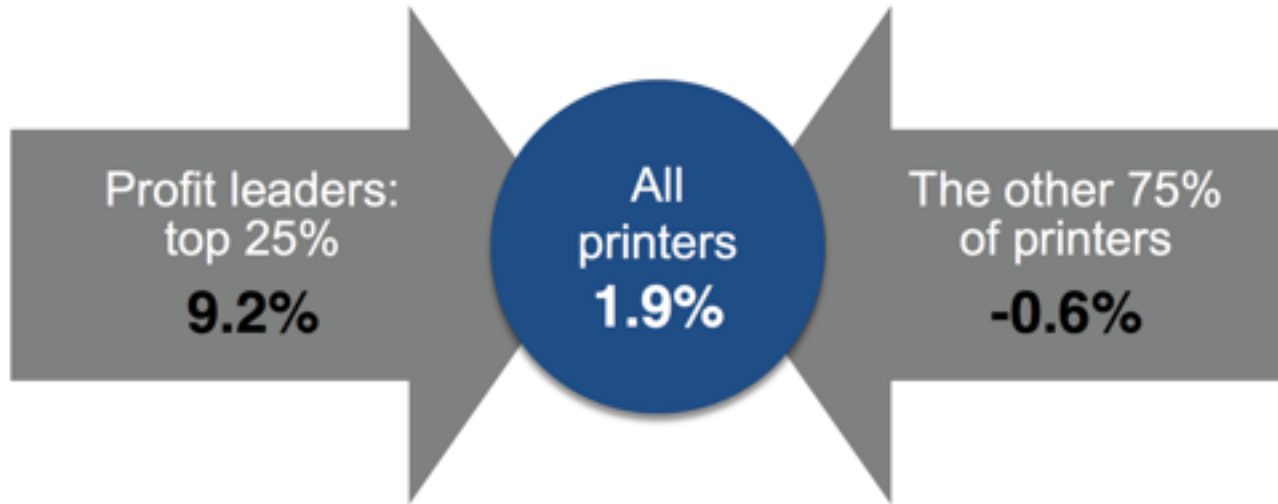
- D50 Profile Connection Space (PCS)
- Colorimetric PCS
- Lack of Handling for Optical Brightening Agents (OBA)
- Lack of Metameric Resistance
- Assumption of Spatial Uniformity

iccMAX Key Areas

- Lighting
 - Non-D50
 - Fluorescence
- Materials
 - Spot Inks
 - Spectral Handling

Why iccMAX?

- Average profits reported by Printing Industries of America



Bottom Line

- Reduce Cost
- Enables Solutions not previously possible
- How?

iccMAX Approach

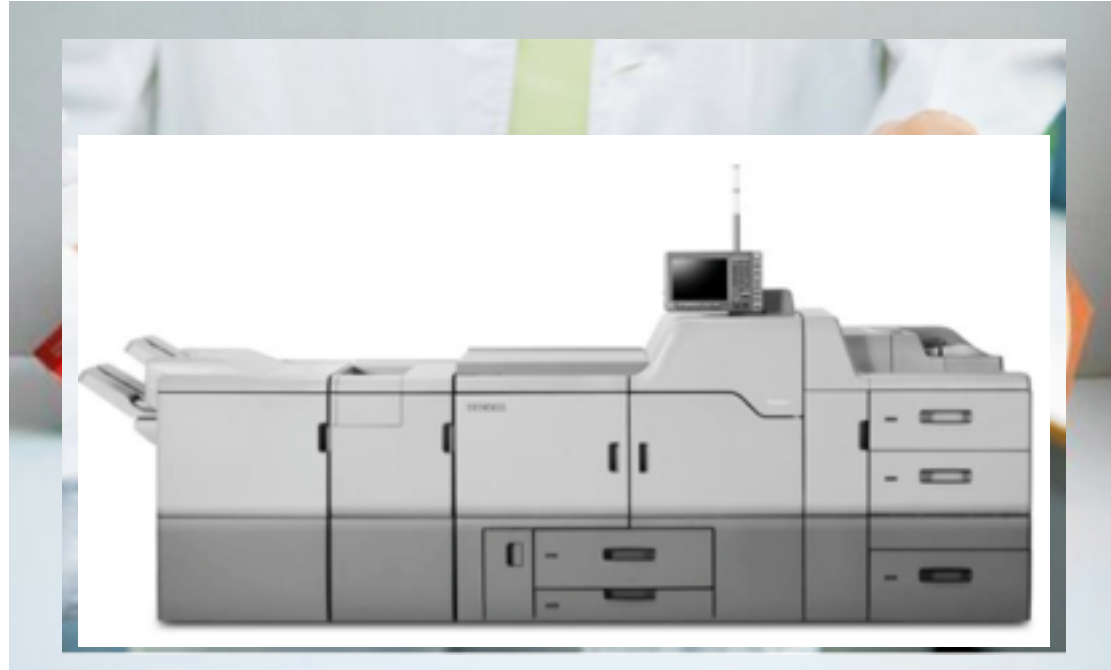
- Open Source Development
 - Reduced risk for individual adopters
 - Improved access to leading research for level playing field
- Flexible Architecture
 - Different application-specific form factors: not “one size fits all” but “many sizes fit all”
 - Reduced implementation cost for adopters, limited to solutions for particular industries

Open Source

- Reference implementation on GitHub
- Many examples
 - Profiles in XML for easy interpretation
 - Conversion to and from XML

Initial Target Markets

- Packaging
- Medical Imaging
- Digital Printing



iccMAX

- iccMAX is a new way of managing color and a new way of collaborating with other companies which manage color
- iccMAX provides unique advancements over v4

iccMAX Overview

- Connection Space Extensions
 - Spectral Profile
 - Material Connection Spaces
 - Support for BRDFs (describe material appearance)
 - Gamut Boundary Description encoding
 - Color Measurement (CxF) tag encoding

iccMAX Workflows

- iccMAX workflows are defined by iccMAX Interoperability Conformance Specification (ICS) documents separate from iccMAX specification
- ICS documents define workflow specific requirements utilizing features of iccMAX specification
- ICS documents will be registered with the ICC for defining various domain specific workflows

iccMAX Workflows

- Not every feature of iccMAX specification needs to be implemented to support an iccMAX based workflow
- Allows for future iccMAX extension

Describing Color ICC.1



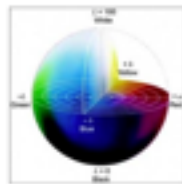
Name



Color Recipe

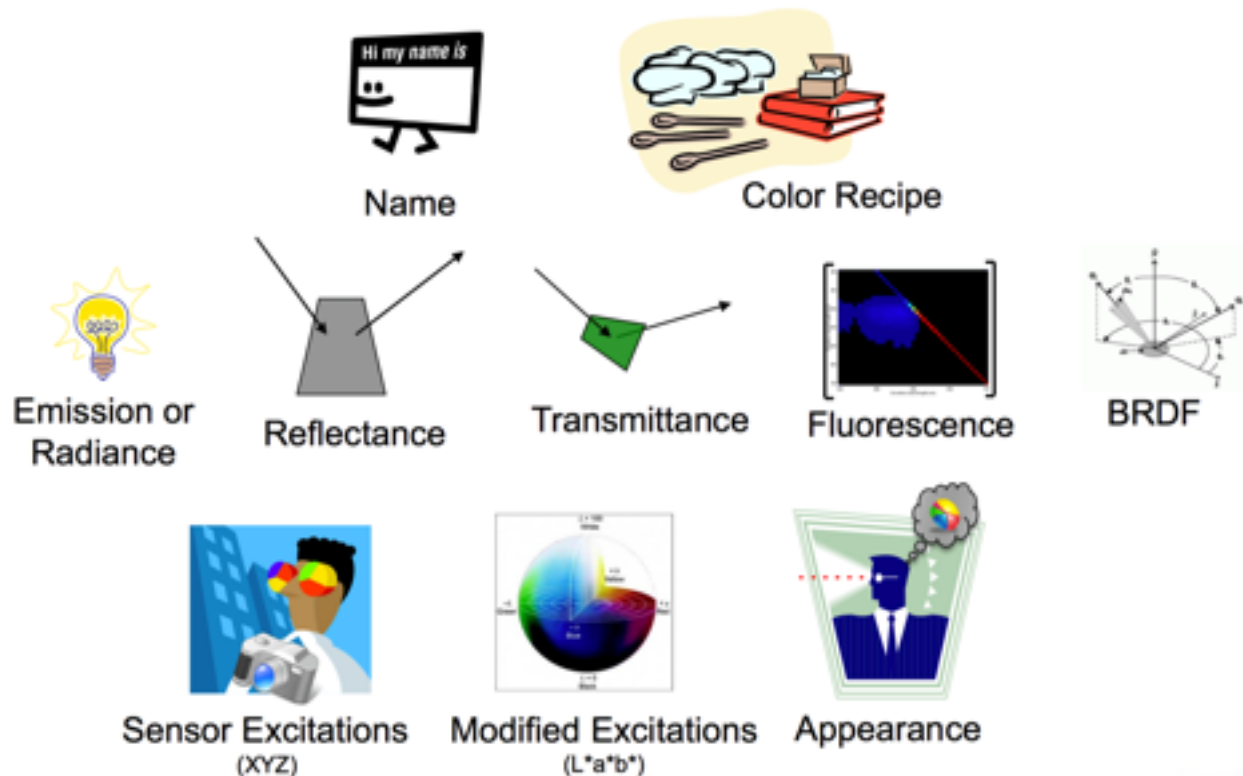


Sensor Excitations
(XYZ)



Modified Excitations
(L*a*b*)

Describing Color in iccMAX



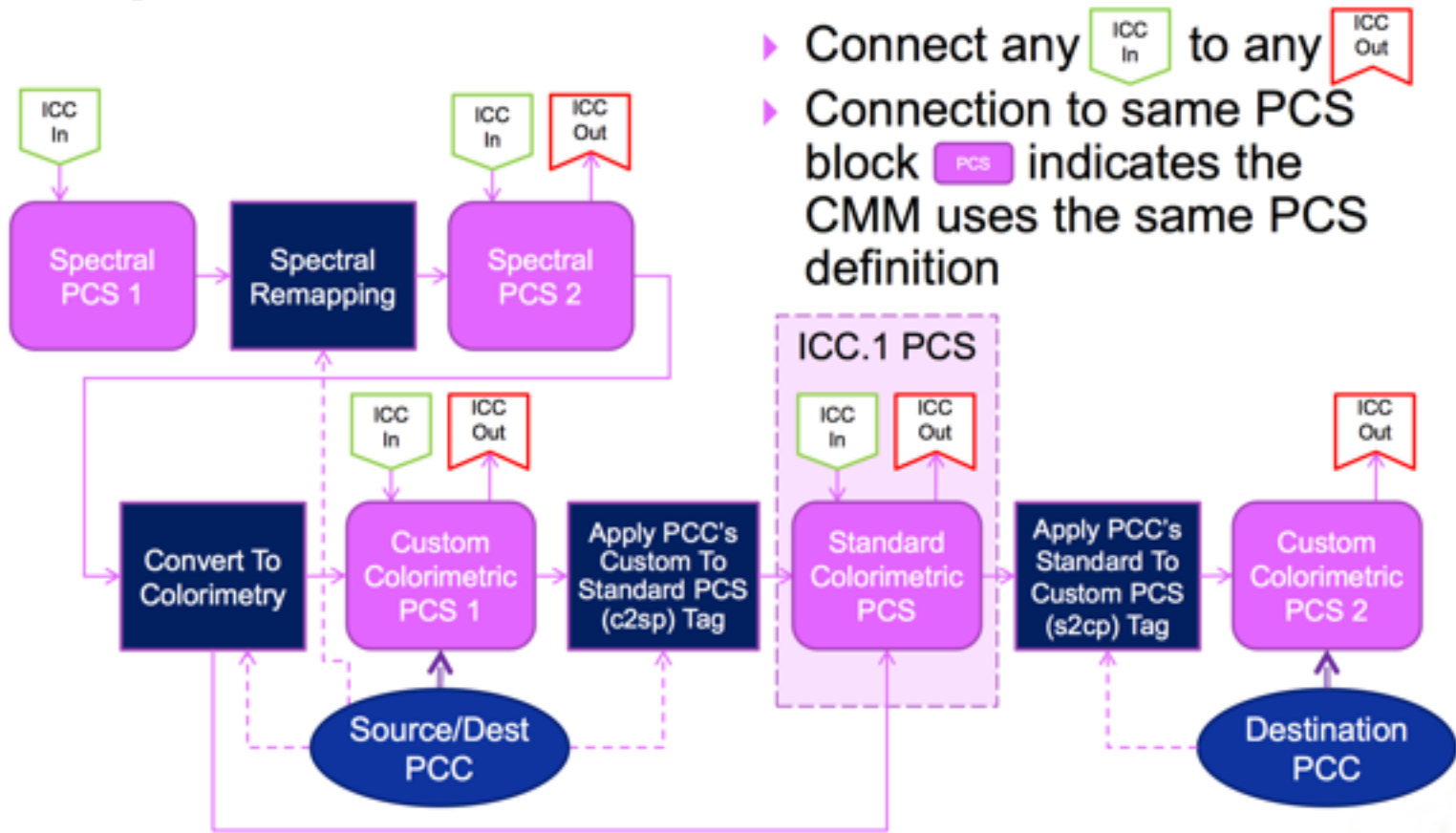
iccMAX Connections

- Named Color Connections
- Colorimetric Connections (how does an observer see it?)
- Spectral Connections (what is its relationship to light?)
- Material Connections (what is it?)
- BRDF Connections

iccMAX PCS Support

<u>ICC.1 PCS Support</u>			<i>From Reflectance</i>	<i>From Transmittance/Transmissive</i>	<i>From Radiant/Emission</i>	<i>From Fluorescence</i>
	<i>From Lab</i>	<i>From XYZ</i>				
<i>To Lab</i>	Yes	Yes	Using PCC	Using PCC	Using PCC	Using PCC
<i>To XYZ</i>	Yes	Yes	Using PCC	Using PCC	Using PCC	Using PCC
<i>To Reflectance</i>	No	No	Yes	Yes	Extract PCC illuminant	Apply then extract PCC illuminant
<i>To Transmittance/Transmissive</i>	No	No	Yes	Yes	Extract PCC illuminant	Apply then extract PCC illuminant
<i>To Radiant/Emission</i>	No	No	Apply PCC Illuminant	Apply PCC illuminant	Yes	Apply PCC illuminant
<i>To Fluorescence</i>	No	No	No	No	No	Exact match required

Spectral & PCS Conversion



Making Connections with iccMAX

- iccMAX provides various ways of communicating about color
 - in terms of visual appearance
 - in terms of physical properties of light and objects
 - allowing for late binding and adjustment of both observer and / or illuminant

Making Connections with iccMAX

- iccMAX separates color management process into separate stages to allow for open, cross-platform implementation
 - device to / from color description transformations (inside profile transforms)
 - conversion between ways of describing color (inside CMM with inter-PCS conversion)
 - this conversion is controlled via Profile Connection Conditions (PCC) either in profiles or separately to CMM

Making Connections with iccMAX

- iccMAX offers new flexible ways of connecting devices like material color channels
 - when color is described by “what is it?” rather than “what does it look like?” or “how does it interact with light?”

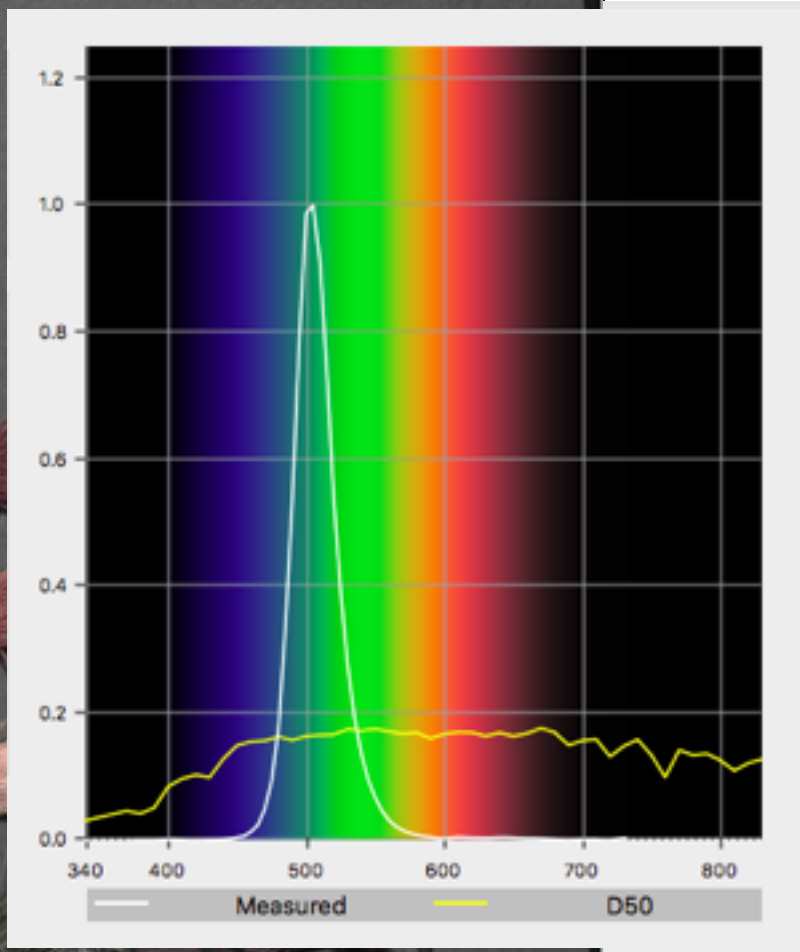
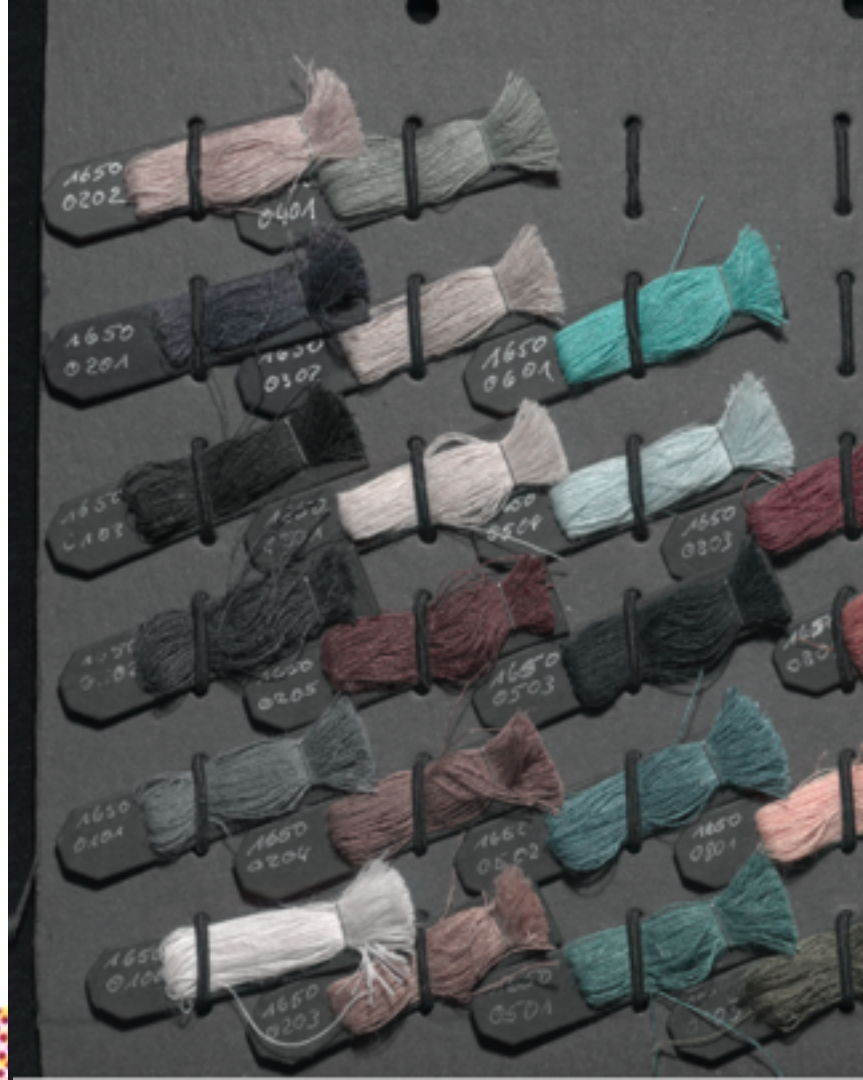
Spectral Imaging

- Caddon
 - Spectral Scanner
 - 16 Filter Wheel



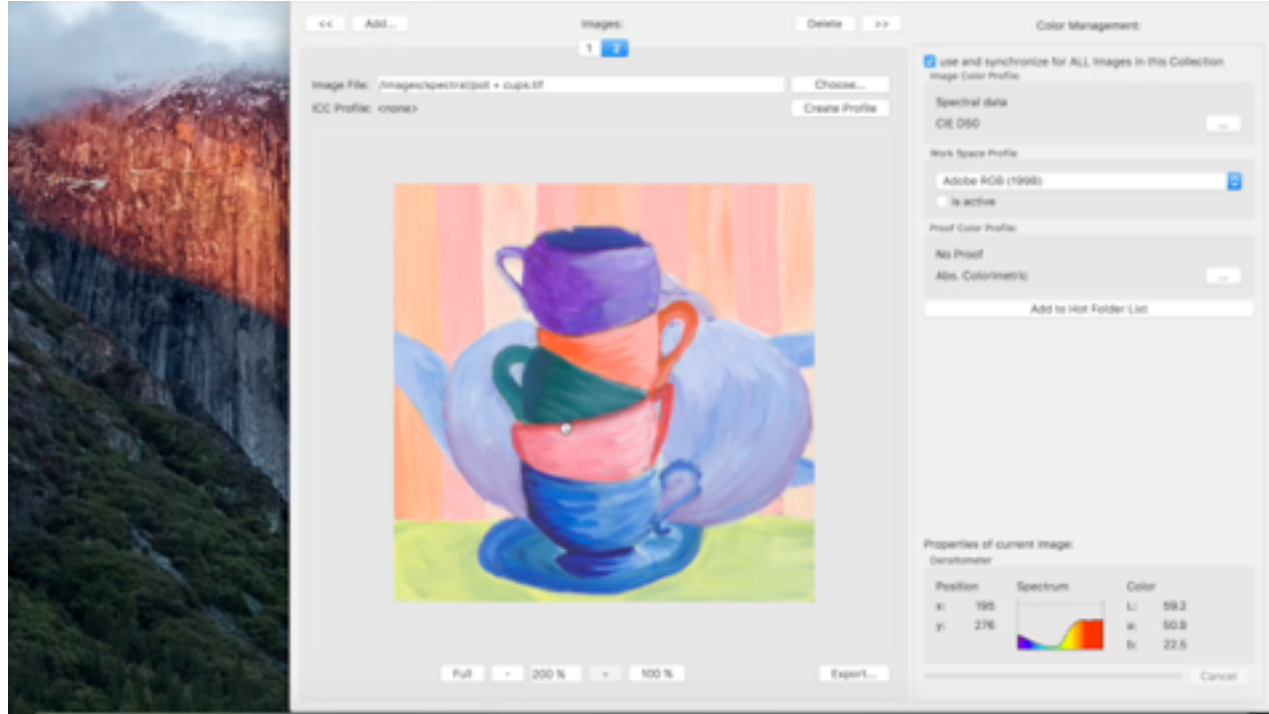
Spectral Imaging

- Color & Appearance Products
- Proof in D65 (outdoors), F2 (store), Std.A (home)
- Packaging
- Textiles
- Wood (decor printing)



Cultural Heritage

- Cobalt blue
- Phthalo blue
- Ultramarine blue

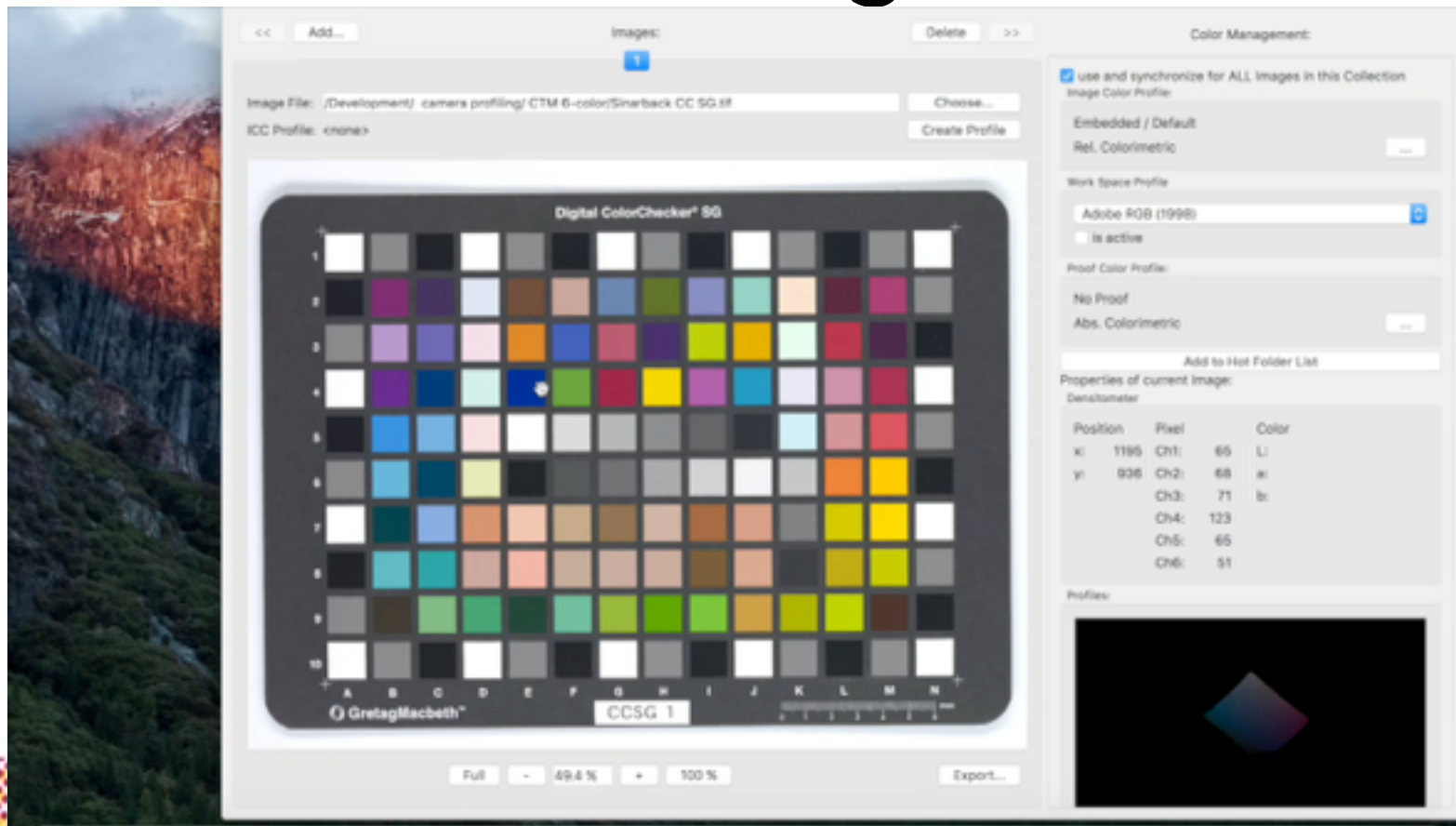


CTM System

- Sinar Color To Match
- remove infrared filter -> “long” red
- one RGB image through yellow filter
- one RGB image through blue-green filter
- = 6 channels (RGB + RGB)
- developed and patented by Francisco Imai & Roy Berns (RIT)
- for image / painting archival



Six Channel Image + Profile



Six Channel Image + Profile

- ICC.1
 - 3-color profile can be done with
 - 3x3 matrix + 3 curves
 - 6-color profile only with 3D Lut
 - can lead to high interpolation errors

Six Channel Image + Profile

- iccMAX
 - n-color profile can be done with
 - $n \times 3$ matrix + n curves
 - $n \times m$ matrix to spectrum
 - high precision
 - no interpolation errors

Verification



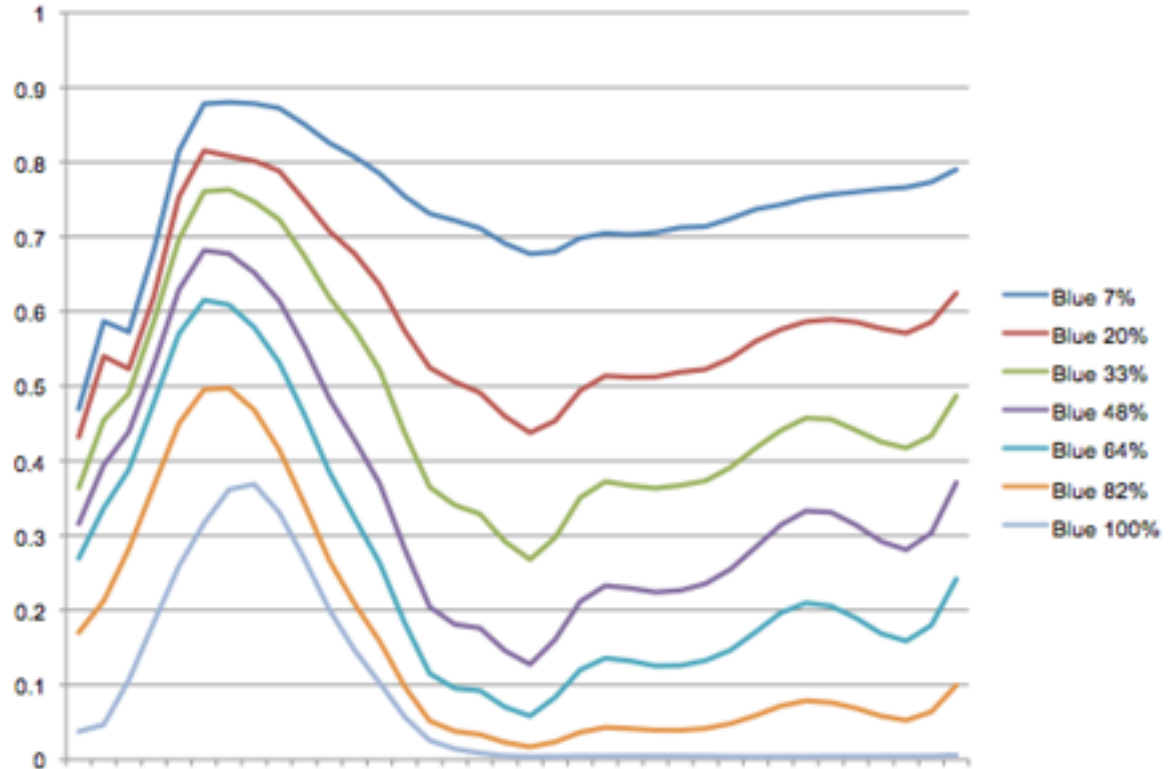
- 40+ Pigmente (Justin)
 - ΔE_{2000} \emptyset 1.2, max 3.5
- 6 blue pigments
 - ΔE_{2000} \emptyset 1.3, max 4.2

Named Colors

- Profile can contain
 - one color
 - large color library
- Defined
 - colorimetric
 - spectrum
 - single color
 - arbitrary ramp

Named Colors

- Blue color
- Component of ICC profile



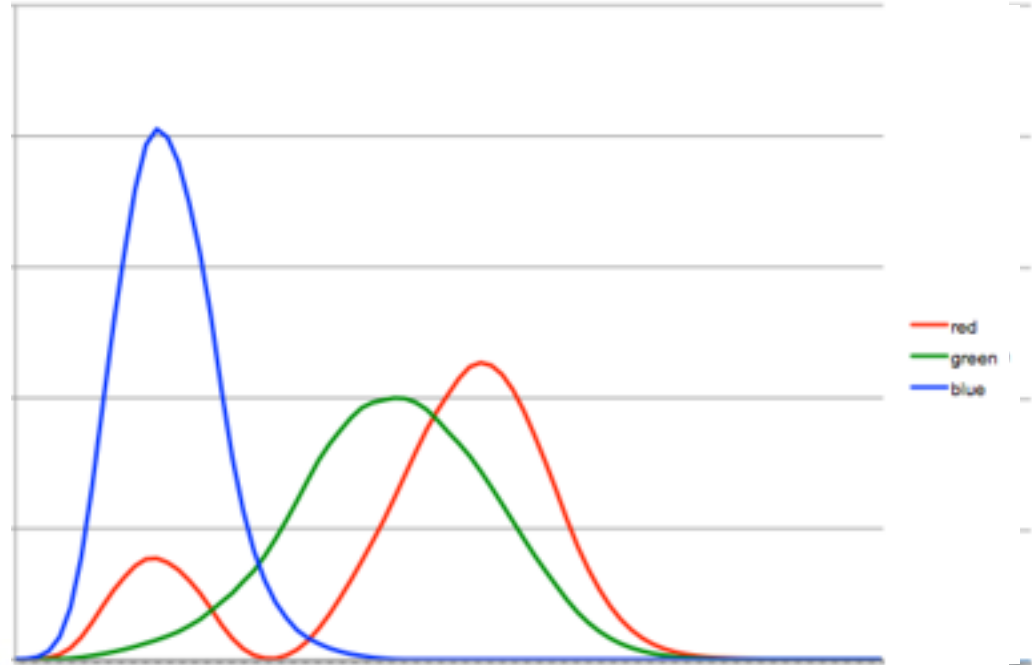
Named Colors

- Fluorescent Colors
 - Neon orange
 - Neon yellow
 - measured by Fluorometer
 - in profile as Donaldson matrix



Display Profile

- Spectral Characterization
 - Backlight
 - Primaries
 - Observer



Display Profile

- In ICC.1 we need a separate profile for each illuminant, .e.g. D50, D65
- In iccMAX we can have one profile
 - redefine spectral viewing condition as profile connection condition (PCC)
 - illuminant
 - observer

Printer Profile

- Spectral Printer
 - many inks (6+)
 - from various pigments
 - spectral “latitude”
 - for printing spectral images

iccMAX

- Everything gets easier when we have spectral characterizations
 - Camera
 - Display
 - Printer
- and spectral images

Spot Colors

- Spectral characterization of ink
 - Ramp printed on paper
 - Ramp printed over black ink
 - Encoded as CxF/X-4
 - ISO 17972-4:2015

Multi-Channel Profiles

- ICC.1
 - n-D tables have equidistant grids
 - CMYK->Lab
 - Grid point every 6% -> 0.5 MB
 - 8-channel
 - Grid point every 11% -> 258 MB

Multi-Channel Profiles

- iccMAX
 - Grids can be arbitrary
 - n -D tables can be replaced by $(n-1)$ -D, e.g. 4D by several 3D tables
 - Calculator Element can be used to filter out unwanted colors

Multi-Channel Profiles

- iccMAX
 - instead of n-D LUT
 - model the behavior of the ink
 - spectral prediction of overprint

Ink Opacity



BRDFs

- Bidirectional Reflectance Distribution Function
- characterizes the behavior of a material
- with regard to light
- measured with gonio spectrometer

BRDFs

-
-



Conclusion

- ICC.1 was the maximum that competing companies were able to agree upon
- Nobody gave up any “secret sauce”
- Resulted in dumb CMM

Conclusion

- iccMAX is largely the PhD thesis of one individual
- Dr. Max Derhak
- with lots of input from color scientists at RIT and the ICC

Conclusion

- iccMAX is an extensible framework
 - no more limitations
 - profiles become the containers for all of our color needs
 - CMM can handle all of the interactions

Conclusion

- the foundation for new innovation has been created
- now we need software that takes advantage of the new capabilities

iccMAX



Thank you.

Questions

